NOAA Technical Memorandum NWS SR-95

UTILITY OF AGRICULTURAL WEATHER SERVICES IN THE MID-SOUTH

W. E. Rench, ESSC, Stoneville, Mississippi

Frank Makosky, WSFO, Little Rock, Arkansas

Scientific Services Division
Southern Region
Fort Worth, Texas
February 1978

UNITED STATES
DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION
Richard A. Frank, Administrator

National Weather
Service
George P. Cressman, Director

UTILITY OF AGRICULTURAL WEATHER SERVICES IN THE MID-SOUTH

W. E. Rench
Environmental Science Studies Center
Stoneville, Mississippi

Frank Makosky
National Weather Service Forecast Office
Little Rock, Arkansas

1. INTRODUCTION

Agricultural weather services recently have been expanded in the Southern Region of the National Weather Service. Agricultural weather forecasts, advisories and outlooks are now written for all major agricultural production areas. How these agricultural weather products are used must be known, especially to Weather Service Forecast Offices, to help answer this question. Agricultural weather services in Arkansas were examined to see what value these products are to farmers and agribusinessmen. These user viewpoints serve as good guides for improving services and should be generally applicable to many other states.

2. STUDY PROCEDURES

2.1 Design of Questionnaire

National Weather Service personnel at Little Rock, Arkansas, Weather Service Forecast Office and Stoneville, Mississippi Environmental Studies Service Center, along with specialists of the Arkansas Cooperative Extension Service developed a questionnaire to meet the stated objectives. Farmers and agribusinessmen were asked about: (1) weather forecast needs; (2) weather advisory needs; (3) communication of agricultural weather information; and (4) other pertinent information.

Farmers and agribusinessmen were asked to rate the importance of forecast elements to their own operation. The list of weather elements included those currently in agricultural forecasts plus other elements Little Rock forecasters thought they could forecast. The time of year each element was needed was also requested. Ratings were based on a scale from 1 to 5, where 1 represents Very Important, and 5 Not Important.

Agricultural weather advisory needs were determined in the same manner.

2.2 Designation of Sample

Extension Service personnel identified thirteen groups as being important enough to sample. Farmer types and the number sampled included: cattlemen-31; poultrymen-21; dairymen-8; hog producers-2; vegetable growers-8; orchardmen-4; and cotton, soybean, and rice farmers-36. Agribusinessmen included: aerial applicators-5; marketing firms-5; radio broadcasters-19; custom operators-2; bankers-8; and machinery dealers-5. Some farmers had both crops and livestock. The number sampled from each group was directly proportional to the size of the group within the state.

State Extension Service Specialists chose the counties and the groups to sample. Each county agent was given the same sampling instructions. Almost all the data were taken in late July and August of 1976.

3. STUDY RESULTS

3.1 Agricultural Weather Forecasts

3.1.1 Relative Importance of Elements by Type of Farmer or Agribusinessman

Relative importance of various forecast elements by type of agricultural business is summarized in Table 1. All groups, except possibly machinery dealers, considered one or more weather variables Very Important (a rating of less than 2.00). Groups differed in their weather forecast needs. Also, some elements in the agricultural weather forecast proved as important as those in public zone forecasts. In fact, a number of agricultural forecast elements were considered more important than some variables in the public forecast. This is particularly relevant because some of these elements are not currently forecast.

The data show another unique feature. As one goes through the production cycle, the relative importance of forecast elements changes. For instance, bankers lend to soybean producers. Both groups consider rainfall probability quite important. Later on, aerial applicators might spray soybeans. Applicators pay attention mainly to rainfall probability, rainfall timing and duration, and wind direction, speed, and shifts. Soybeans are then channeled through marketing firms who look mainly at rainfall probability, rainfall timing, and drying conditions. Poultry producers then buy soybean meal for feed. Daily extremes in air temperatures are important to poultrymen . However, poultrymen pay little attention to rainfall probability. So, to get eggs and broilers produced, several groups having particular needs have been part of the production line. If forecasts do not meet needs of all the groups, the production line can be made less efficient (having effects on groups seemingly unrelated).

Table 1 shows, also, that Arkansas agricultural forecasts are utilized. For example, a reference to drying conditions is not in any other forecast product but was rated important by many groups.

3.1.2 Relative Importance of Forecast Elements by Extension Service District

The data on agricultural weather forecasts were also examined by Extension Service Districts and are summarized in Table 2. The Northeast District and much of the Southeast District is in the Arkansas Delta.

Rainfall probability was rated as Very Important in all districts. There was a slight tendency for this element to be used more in the Delta (the main area of crop production). Average maximum daily rainfall ranged from Useful to Not Important. It was not used much in the northwest. Average daily rainfall ranged from Useful to Not Important in the various districts.

TABLE 1.

[1]Relative Importance of Weather Parameters to Certain Groups of Arkansas Farmers and Agribusinessmen in 1976.

PARAMETER \ GROUP	Relative Importance by Group												
	* 1	2	3	4	5	6	7	8	9	10	11	12	13
Rainfall probability	1.24	3.14	1.00	2.67	1.50	1.50	1.31	1.57	1.50	1.11	1.13	2.33	1.67
Average maximum daily rainfall	3.76	3.86	4.00	3.33	2.00	3.83	3.41	3.57	3.50	3.56	2.38	4.33	3.44
Average daily rainfall	3.73	4.20	3.50	3.33	3.50	3.33	3.56	3.57	3.50	3.33	2.88	4.33	3.25
Rainfall timing and duration	2.00	2.35	2.38	2.33	1.50	1.67	2.22	1.86	4.00	2.78	2.13	2.00	2.95
Maximum air temperature	2.79	1.42	2.86	1.67	2.50	2.83	2.27	3.43	5.00	2.11	2.13	2.67	1.95
Minimum air temperature	2.86	1.50	2.57	1.67	2.00	2.50	2.25	3.29	5.00	2.22	1.50	3.33	1.95
Rate of temperature change	3.10	2.30	3.14	3.00	2.00	3.33	3.39	3.29	3.50	3.89	2.50	2.33	3.06
Wind direction	3.03	3.10	4.00	3.00	3.00	1.17	2.91	4.29	2.50	3.00	3.13	4.33	2.65
Average wind speed	3.00	2.74	4.50	2.67	2.25	1.83	2.83	3.57	4.00	3.33	3.00	3.67	2.82
Timing of wind shifts	3.69	3.11	4.83	3.00	3.25	1.67	3.42	4.29	2.50	4.00	3.88	4.33	3.69
Time winds go above or below 5-7 MPH	3.76	3.05	3.88	3.00	1.75	2.17	2.94	4.00	3.50	4.11	2.50	4.33	3.63
Soil temperature	2.63	4.15	2.14	3.67	3.50	4.00	1.75	3.43	3.50	2.22	1.88	3.00	3.31
Hours sunshine	2.77	2.95	2.57	3.00	2.50	4.17	2.72	3.43	4.50	2.56	2.75	2.00	2.72
Timing of sunshine	3.31	3.22	3.83	3.00	1.75	4.17	3.28	3.67	4.50	3.56	3.50	3.67	3.21
Dew formation time	3.30	3.95	3.33	3.33	4.00	3.83	3.08	3.43	3.00	3.78	3.63	2.67	2.81
Dew dry off time	2.40	3.85	3.17	3.00	3.50	3.33	2.47	3.14	2.00	2.89	3.38	2.33	2.44
Average dew point	4.07	4.22	4.00	3.33	2.00	4.17	3.83	4.43	5.00	4.00	3.50	3.00	2.53
Dew point change	4.00	4.22	3.33	3.67	2.25	4.17	4.09	4.43	5.00	4.00	3.38	4.33	3.00
Drying conditions	1.93	2.89	1.86	3.00	1.75	3.33	2.05	1.86	2.00	2.11	2.00	2.00	2.24
Minimum relative humidity	2.72	2.68	3.33	1.33	2.25	3.83	2.53	2.57	2.50	3.11	2.86	2.33	2.19
Time of day when RH is going to drop below or rise above 60%	2.93	2.84	3.67	2.00	3.00	3.50	2.53	2.86	2.50	2.75	3.13	3.00	2.27

* Groups are: 1-beef farmers; 2-poultry farmers; 3-dairy farmers; 4-hog producers; 5-fruit growers; 6-aerial applicators; 7-cotton/rice/soybean farmers; 8-marketing firms; 9-custom operators; 10-bankers; 11-commercial vegetable growers; 12-machinery dealers; and 13-broadcasters.

[1] Relative importance is: 1-2 Very Important; 2-3 Important; 3-4 Useful; 5 Not Important

TABLE 2.

RELATIVE IMPORTANCE OF WEATHER ELEMENTS
IN ARKANSAS EXTENSION SERVICE DISTRICTS

ELEMENTS	DISTRICT					
	NORTHWEST	NORTHEAST	NORTHCENTRAL	SOUTHWEST	SOUTHEAST	STATE
Rainfall Probability	1.59	1.44	1.60	1.58	1.34	1.55
Average Maximum Daily Rainfall	4.14	3.44	3.25	3.25	3.66	3.94
Average Daily Rainfall	4.07	3.25	3.17	3.38	3.79	3.56
Rainfall Timing and Duration	2.19	1.63	2.24	2.48	2.69	2.32
Maximum Air Temperature	2.45	2.69	2.04	2.18	2.38	2.28
Minimum Air Temperature	2.35	2.56	1.96	2.29	2.17	2.26
Rate of Temperature Change	2.93	3.25	3.13	2.85	3.38	3.07
Wind Direction	3.40	2.88	2.74	3.15	2.75	3.02
Average Wind Speed	3.28	2.81	2.83	3.00	2.83	2.97
Timing of Wind Shifts	3.50	2.81	3.70	3.87	3.52	3.53
Time Winds Go Above or Below 5-7 MPH	3.28	3.44	3.25	3.41	3.19	3.31
Soil Temperature	3.21	2.50	3.26	2.98	2.14	2.83
Hours Sunshine	3.03	2.88	2.88	2.78	3.10	2.93
Timing of Sunshine	3.29	3.57	3.26	3.18	3.83	3.44
Dew Formation Time	3.38	3.06	3.22	3.67	3.59	3.45
Dew Dry Off Time	3.07	2.69	3.43	3.18	2.86	2.92
Average Dew Point	3.54	4.00	3.43	3.76	4.14	3.73
Dew Point Change	3.88	4.33	3.26	3.73	4.21	3.87
Drying Conditions	2.17	2.19	2.08	2.41	2.41	2.29
Minimum Relative Humidity	2.41	2.75	2.57	2.63	3.04	2.65
Time of Day When RH Is Going to Drop Below or Rise Above 60%	2.63	2.53	2.54	2.95	3.14	2.83

Farmers seem to want to know when and where it is going to rain, as indicated by samples taken in all districts. In the Delta, this was as important as rainfall probability. District averages of rainfall timing ranged from Important to Very Important.

Maximum and minimum air temperatures are important in all districts. Rate of temperature change (not currently predicted) was rated from Useful to Important. Rate of temperature change seems more important in hill sections of the state. Wind direction is important in Delta counties, and Useful to Important in hill counties. Average wind speed took on about the same importance as wind direction in each district. Timing of wind shifts is Important in the northeast and Useful elsewhere.

The time of day winds rise above and go below seven miles per hour is Useful across the state. Soil temperatures are rated Important to farmers of the Arkansas Delta and Useful in other regions, particularly to vegetable growers. The hours of sunshine are Useful to Important. There is little difference between Delta and hill sections. Sunshine timing seems useful. There is a small tendency for sunshine to be asked for more in the hills. Sunshine timing is not as important as hours of sunshine. Dew formation time is useful information. However, dew dry-off time is Useful to Important, being more important in Delta counties.

Average dew point ranged from Useful to Not Important and was least important to Delta farmers. Dew point change is even less important than average dew point.

Those sampled indicated that the drying conditions forecast is important in all Extension Districts. Apparently, farmers make more use of this forecast than the individual elements such as maximum temperature, sunshine, dew points, etc. in order to estimate drying rates. Drying conditions is one of the most important elements in the Arkansas agricultural weather forecast that is not in any other product now issued by the Little Rock Weather Service Forecast Office.

Minimum relative humidity is Important to Useful. Time of day when relative humidity is going to drop below or rise above 60% is also Important in most districts.

3.1.3 Relative Importance of Forecast Elements over Arkansas

Table 2 also contains the average importance of elements across the state. The averages cluster into five main groups. Rainfall probability is by far the most important and in a group by itself. Minimum air temperature, maximum air temperature, drying conditions and rainfall timing and duration are important to Arkansas agricultural interests, overall. Minimum relative humidity is in a group by itself. Soil temperature, timing of 60% relative humidity, dew dry-off time, hours sunshine, average wind speed, wind direction, and rate of temperature change clustered in a group. The rest of the elements can be grouped together.

TABLE 3.

Percent Using Element Each Month

Elements	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Rainfall probability	37	37	49	71	78	88	84	80	71	59	51	35
Average maximum daily rainfall	42	45	54	80	85	89	93	87	70	61	51	42
Average daily rainfall	48	52	62	83	88	92	92	91	80	65	59	48
Rainfall timing and duration	39	42	49	77	82	89	92	91	72	58	50	39
Maximum air temperature	47	49	50	64	69	79	84	85	60	52	49	47
Minimum air temperature	68	72	69	68	68	61	60	60	54	52	52	66
Rate of temperature change	67	68	68	77	80	74	73	69	71	65	62	65
Wind direction	50	53	55	73	79	80	79	70	54	53	46	50
Average wind speed	44	45	47	64	80	91	85	74	58	55	45	44
Timing of wind shifts	51	53	58	78	85	90	85	78	63	61	54	51
Time winds go above or below 5-7 MPH	37	40	51	75	80	85	81	76	53	51	41	37
Soil temperature	11	13	37	88	88	42	31	29	19	17	15	11
Hours sunshine	42	42	54	65	73	76	75	71	60	56	45	42
Timing of sunshine	43	48	55	65	71	78	78	74	63	57	51	43
Dew formation time	20	20	23	32	41	65	62	64	64	61	54	20
Dew dry off time	14	14	19	26	39	68	67	64	63	57	45	14
Average dew point	28	30	35	54	58	74	74	72	68	63	54	28
Dew point change	25	29	35	55	60	78	78	76	67	62	55	25
Drying conditions	22	22	27	41	52	79	77	77	62	56	44	22
Minimum relative humidity	33	34	39	46	54	78	79	80	72	67	56	33
Time of day when RH is going to drop below or rise above 60%	32	33	37	48	54	74	75	76	73	68	56	32

3.1.4 Use of Weather Forecasts by Agriculture Through the Year

Those interviewed were also asked when they needed an element during the year. Table 3 shows the percent using each element by month for the entire state. All, except minimum air temperature, were used least during the winter. The most intense use of weather forecasts was during the summer months. However, the results indicate that use of elements that are exclusively in the agricultural weather forecast does not decline to zero. There is enough use of these elements to justify issuance of both morning and evening agricultural weather forecasts year round. This is especially true during mild winters when farmers are able to work fields.

3.2 Agricultural Weather Advisories

Producing crops and livestock demands that many weather variables be simultaneously considered in order to make good, timely decisions. Farmers were asked to rate the relative importance of several tasks on which they would like to have weather advisories. Results in Table 4 show that farmers would very much appreciate weather advisories on half of the tasks mentioned. The average for shipping poultry would have had more relative importance if poultry shippers themselves had been questioned since most poultry farmers do not ship their own birds.

TABLE 4.

Average Relative Importance of Weather Advisories to Arkansas Farmers

Farming Task	[1]Average Relative Importance
Planting	1.45
Applying chemicals	1.44
Irrigating	2.68
Harvesting grain or cotton	1.46
Harvesting hay	1.32
Controlling poultry heat stress	1.29
Controlling poultry cold stress	1.67
Managing grazing of pastures	1.97
Shipping poultry	3.13
Shipping cattle	2.37
Drying grain	2.23
Aerating grain	2.24
Fertilizing pastures	1.86
Completing cattle management practices	2.45
Defoliating cotton	2.52
Controlling plant diseases	2.20

[1]Relative Importance: 1-2 = Very Important; 2-3 = Important; 3-4 = Useful; 4-5 = Not Important. Average for each task was calculated from data given by representative farmers (only poultrymen were included in the average for poultry heat and cold stress, etc.).

Time of year that farmers wanted weather advisories on particular tasks closely matched crop and livestock production calendars. Examination of Arkansas crop and livestock calendars shows a need for agricultural weather advisories all year across the state.

3.3 Communicating Agricultural Weather Information

Several questions were asked about communicating weather products to farmers and agribusinessmen. Each person interviewed was asked his first, second, third, and fourth choices for broadcast time of agricultural weather forecasts and advisories. This did not vary much between regions and business types, so state averages are meaningful. They are summarized in Table 5.

TABLE 5.

Farmer and Agribusinessmen Choices of Broadcast Time

Time of day	Percent Favoring Each Time			
	First Choice	Second Choice	Third Choice	Fourth Choice
0500-0830	74	28	13	17
0830-1100	0	13	5	7
1100-1330	10	40	36	16
1330-1630	0	0	5	5
1630-2030	7	9	27	20
2030-2400	9	10	14	35

Agricultural users tended to choose early morning broadcasts first. Just a few chose noon hours, early evening, and late evening as their first pick. Second and third choices of broadcast time were not as clear cut. The time period between 11:00AM and 1:00PM was slightly favored. Fourth choice of broadcast time was clearly during late evening hours, although other hours were important fourth colces. The data show that farmers and agribusinessmen tend to listen to weather information all through the day.

Secondly, farmers and agribusinessmen were asked what percent of their weather information comes from radio, television, newspapers, and other sources. Broadcasters were excluded from the average, since the question is not relevant to that group. Results are that 40 percent of agricultural weather information comes from radio, 51 percent from television, 5 percent from newspapers, and 4 percent from other sources. The other source most frequently mentioned was the Federal Aviation Administration. Aerial applicators used this source the most of the groups examined.

Around 91 percent of those reporting said their local television or radio station broadcasts agricultural weather forecasts and advisories.

Farmers were additionally asked how valuable hourly television broadcasts of latest satellite and radar data would be to their operation. Each person interviewed was asked to rate such broadcasts very valuable, valuable, or of little value. The responses averaged between valuable and very valuable.

Comparisons of relative importance of forecast elements between broadcasters and the rest of those sampled are shown in Table 6. Generally speaking, broadcasters gave more importance to weather than the agricultural user did although there are a few elements on which broadcasters need to place more importance. These include rainfall probability, rainfall timing and duration, and soil temperatures (mainly in Delta counties). Rainfall timing and duration could be given more emphasis if broadcasters would transmit hourly weather radar summaries frequently. Both broadcasters and their public would benefit from such action.

Table I indicates that broadcasters would benefit if they would analyze their market with respect to the types of agricultural users in their area. For 14 out of 27 weather elements considered, one or more agricultural groups thought a particular weather element was more important than did broadcasters. For example, broadcasters gave soil temperatures a relative importance rating of 3.31. Cotton, soybean, and rice farmers gave soil temperatures a rating of 1.75. Radio stations serving the Arkansas Delta that do not broadcast soil temperatures in the spring could be losing potential listeners.

TABLE 6.

[1]Relative Importance of Weather Forecast Elements to Broadcasters and Agricultural Users

Parameter	Broadcasters	Users
Rainfall probability	1.66	1.50
Average maximum daily rainfall	3.44	3.55
Average daily rainfall	3.25	3.60
Rainfall timing and duration	2.95	2.22
Maximum air temperature	1.95	2.37
Minimum air temperature	1.95	2.30
Rate of temperature change	3.06	3.07
Wind direction	2.65	3.08
Average wind speed	2.82	2.99
Timing of wind shifts	3.69	3.55
Time winds go above or below 5-7 MPH	3.63	3.27
Soil temperature	3.31	2.78
Hours sunshine	2.72	2.98
Timing of sunshine	3.21	3.41
Dew formation time	2.81	3.51
Dew dry-off time	2.44	2.97
Average dew point	2.53	3.92
Dew point change	3.00	3.97
Drying conditions	2.24	2.32
Minimum relative humidity	2.19	2.74
Time of day when relative humidity is going to drop below or rise above 60%	2.27	2.89

[1]Relative importance is based on the same scale as used in Table I.

3.4 Other Pertinent Information

Other information generally related to Arkansas' agriculture weather service program was also gathered. Farmers were asked if they use rain gages, air thermometers, and soil thermometers. Around 92 percent use a rain gage and 76 percent used air thermometers. Most cotton producers use soil thermometers.

Around 70 percent of those interviewed knew there were special agricultural weather services available to them.

A good 93 percent of those reporting said present day weather forecasts help them plan operations better than ten years ago.

Of the farmers replying, around 73 percent said they made large yearly adjustments in planting crops. Climatic probabilities were used as a general timing scheme for planting by the rest of the farmers.

Apparently, most aerial applicators are able to schedule spraying around the weather.

About 68 percent said that weather forecast two days ahead was sufficient for them to complete weather sensitive operations. Of those that said two days were not enough, several said five days were needed.

Many were unable to estimate the yearly costs of insufficient and inaccurate weather information. However, the responses clearly show that insufficient or inaccurate weather forecasts and advisories are costly. Many felt better services could add between $1000 and $10,000 to their yearly gross income.

4. CONCLUSIONS AND RECOMMENDATIONS FOR IMPROVING ARKANSAS' AGRICULTURAL WEATHER SERVICE PROGRAM

The survey results show that some changes in the Arkansas Agricultural Weather Program are needed. We would make more efficient use of forecaster's time if the average maximum daily rainfall, average daily rainfall, dew formation, and dew point temperatures were deleted from the agricultural forecast to give forecasters time for more important elements.

Agricultural forecasts would be improved by adding the time of day relative humidity will drop below and rise above 60 percent (especially in the Arkansas Delta). Temperatures were very important to Arkansas' $600 million poultry industry. Timing of occurrence of 90° and 32° temperatures, if applicable for any one day, would be very helpful to poultrymen. Aerial applicators have special interest in winds during the crop season and they need wind forecasts for the third period of the morning forecast.

The study shows there would be little value of adding rate of temperature change, timing of sunshine, and change in dew point temperature to the forecast. Forecasting techniques for the elements exclusively in the agricultural weather forecast need improving. Those involved are drying conditions, dew dry-off time for the current morning, winds for the next day, and rainfall timing and duration. All these elements were important to Very Important to large segments of Arkansas agriculture.

The study results also give directions for Arkansas advisory services. High priority should be placed on keeping advisories matched with present farming technology. Priority should also be given to incorporation of results from appropriate new agrometeorological research that proves beneficial to Arkansas agriculture. The study indicates that research into livestock-weather relationships needs to be stepped up, so better advisories could be written for livestock producers.

Improvements in communicating agricultural weather information are needed. These improvements include frequency of transmission, time of transmission, and method of communication. Agricultural weather users keep up with weather throughout the day, and issuance of three products daily (morning and evening agricultural weather forecasts and midday advisories) should be continued all through the year.

It is important to note that many farmers would like to have more frequent and thorough weather briefings by television. Video transmission of radar and satellite imagery each hour, along with other mesoscale surface features, furnished by the National Weather Service would fulfill this need by giving farmers a personalized weather briefing service, such as pilots now receive.

5. ACKNOWLEDGEMENTS

The authors appreciate the significant contributions of the Arkansas Cooperative Extension Service in gathering data for this work. Thanks are also due the farmers and agribusinessmen who took time to participate in this study.